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TRIANGULAR *VERSUS* SQUARE PLANTING

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Square planting is the commonest practice, and is also the arrangement generally recommended in textbooks on Silviculture. Triangular and quincunx plantings are merely mentioned as possible variations and are only seen in orchards. Why this is so is, however, nowhere clearly stated.

It is sometimes contended that triangular planting is not in favour because—

(1) Physiologically it offers no special advantage over square planting;

(2) The fixing of plant positions is more difficult and expensive; and

(3) Mechanical thinnings to the required intensities cannot be easily carried out.

These prejudices are critically examined in the paragraphs that follow.

There is no definite evidence or indication regarding the pattern to which plant positions approach in nature, in normally stocked crops. Taking the simplest case, *viz.*, a naturally grown crop, standing on a uniform site and containing trees of similar vigour and form, will they tend to arrange themselves in the manner of—

(*i*) *Square* planting, *i.e.*, will they be situated at the points of intersection of two sets of equidistant parallel straight lines at right angles;

(*ii*) Rectangular planting, assuming that wind direction, side-shade, rotation of the earth, or even a regular site-quality or topographical gradient results in larger crown-spread in one direction;

(*iii*) Triangular planting;

or, will they be distributed in a truly random manner? For instance, will teak plants with their decussate branching arrange themselves in the manner of square planting? There is no such evidence forthcoming, obviously because even if decussate branching were likely to promote crown development in the case of free growing trees, in four directions separated by 90° in a crop where the direction of branching will vary from tree to tree, the effects will tend to get obliterated. For the same reason, although the trees may all have a *somewhat elongated* 'crown' in any particular direction to better withstand the force of the wind, or say, to fully utilise the available sunlight or shade, these factors are not likely to affect the distribution in other directions of the compass. Thus at best the plants will tend to distribute themselves in parallel lines with longer espacement in the direction of wind, etc. Examples of this can often be seen along the edges of plantations and in wind belts.

On the other hand, if the surviving plants, which are assumed to be of equal vigour and similar form, *have a natural tendency to* make the best use of the available soil reserves and sunlight, they can only do this if they are situated at the vertices of equal equilateral triangles, when they can develop radially in all directions. The nearest approximation to compactly packed equal circles are regular and equal hexagons, because no regular polygons with sides greater than six can fully cover a plane surface. It would thus be quite reasonable to assume that, to best utilise the available growing space the plants will tend to distribute themselves so as to be at the centres of closely packed hexagons, *viz.*, in the manner of triangular planting.

If this is conceded, triangular planting should be preferred to square planting at least from the physiological point of view. There is indirect evidence in support of this deduction. When natural crops are thinned by the "rod method" with a view to evenly space out the stems, the number of stems over a unit of area is nearer the theoretical figure obtained from the triangular planting formula, *viz.*, $N = \frac{\sqrt{3}}{2} \cdot \frac{A}{d^2}$ than the figure obtained from the square planting formula, *viz.*, $N = A/d^2$, where N is the number of stems, A is the area over which they stand, and d is the distance between the adjacent stems. When d is 6 feet, N per acre is 1398 and 1210 for triangular and square planting respectively. In general, the number under triangular orientation is 115.5 per cent. of the corresponding number under square orientation.

The second contention that it is comparatively more difficult and expensive to fix plant positions for triangular planting is not supported by any factual evidence. Here is a simple method which will compare favourably with the usual methods employed for fixing plant positions for square planting.

Staking for triangular planting.—(See Fig 1).—Fix a central stake O on a fairly level ground and round it draw a circle of say one chain radius. On the circumference starting from any point A, mark points B, C, D E and F so that chords AB, BC, etc., are each one

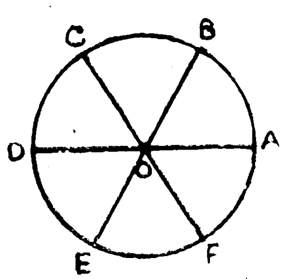


Fig 1

chain in length. Join AD, BE and CF, produce them both ways and fix stakes on these lines starting from O and spaced at the requisite distance d. The space between the lines can be easily filled up by using two rods of length d and holding them so that one end of each is above two adjoining stakes and bringing the other ends together to get the position of the new stake. At any point on a line the directions of the other two lines can easily be determined without the use of a compass, by drawing a circle round the stake and cutting it by chords AB and DC where O is the middle stake and A and B are adjacent stakes on the line DOA. Lines can always be straigthened by aligning.

If the drawing of a cirlce at every step and then determining the directions of the lines is considered too cumbersome, the simple instrument illustrated in *Figure* 2 may be used. It consists of a wooden staff say one inch diameter and five to $5\frac{1}{2}$ feet long, depending on the height of the person using it. The lower end has an iron spike for driving the staff in the ground. On the upper end a

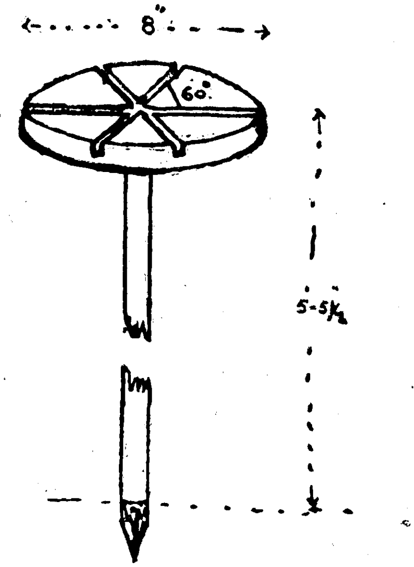


Fig 2

wooden disc eight inches in diameter and one inch thick is fixed centrally and at right angles to the staff with three equally-spaced slits, 1/8 inch wide, cut into it up to a depth of say half inch. It is hardly necessary to say how the instrument is to be used.

Lastly there is the assertion that mechanical thinnings cannot be so easily carried out

with triangular orientation. This assertion seems to be based more on ignorance than on anything else. In fact, as will be seen from the subsequent paragraphs, mechanical thinnings can be carried out as easily as with square arrangement. What is more important, a larger number of variations are possible under triangular planting and thus thinnings to various intensities can be carried out, and it is possible to give more or less uniform growing space to the stems retained. These are illustrated in *Figures 3 to 8*. In all these figures the plant positions are indicated by dots and the growing space available for each plant is indicated by lines between adjacent plants.

Figure 3 (portion marked A, ignoring the cross hatch) shows a rectangular area of a plantation containing 100 plants. It will readily be seen that if d is the distance between adjacent plants the growing space available per plant is $d^2 \times \sqrt{3}/2$, *i.e.*, roughly 31.14 square feet when $d=6$ feet.

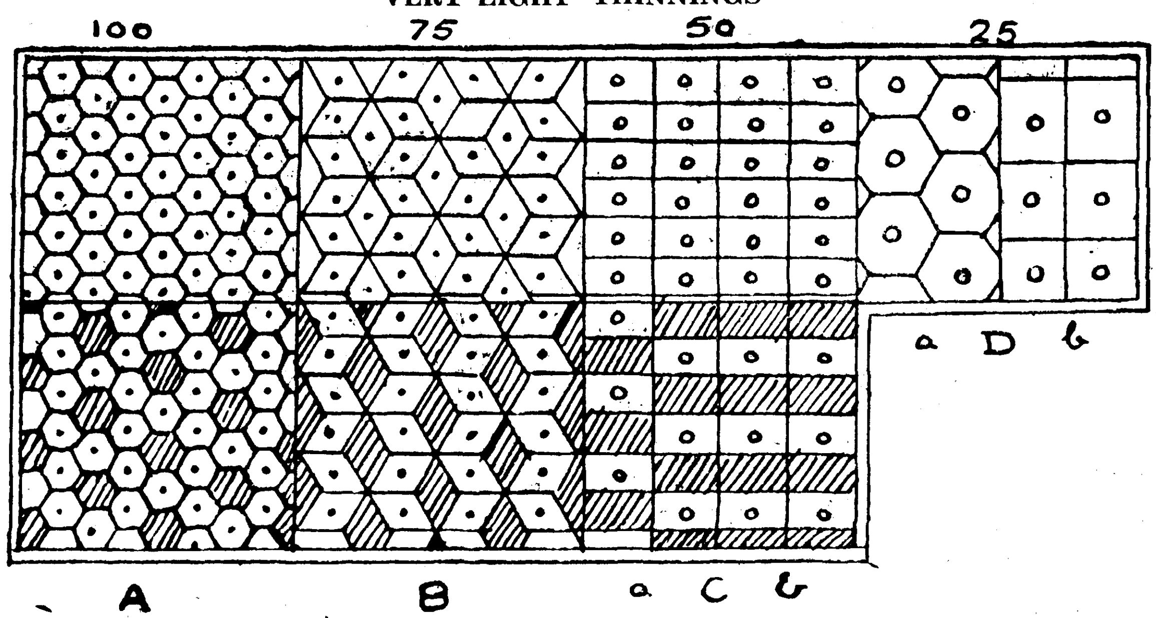
The various intensities of mechanical thinnings that may be carried out are illustrated in *Figures 3 to 7* and an increment felling in *Figure 8*. The terms "very light thinnings," "light thinnings," etc., used by me, are not used in the same sense in which they are used in the standardised grade thinnings of Howard.

Very Light Thinnings. (Fig. 3).

Thinning ...	I	II	III
Stems retained ...	75%	50%	25%

The upper half of A shows the unthinned crop. The first thinning reducing the stems to 75 per cent. is marked in the lower half. The growing space made available for these stems is shown in the upper half of B. It will be seen that the growing space is not hexagonal but rhomboidal in shape. In other words, the trees have been given freedom to grow only along the longer diagonals of the rhombus. These diagonals are uniformly distributed in three directions separated by

Fig 3
VERY LIGHT THINNINGS



120° which is a better approximation to natural conditions than the arrangement obtained under line-thinnings when all retained plants are forced to grow in the same direction of the compass, *i.e.,* into the space left vacant by the line of plants removed. The lower half of B shows the second thinning marked, reducing the stems to 50 per cent. of the number at planting. The growing space made available to these stems is

shown in the upper half of C. This space is now rectangular in shape and the stems will thus have freedom to develop in two directions in which their growth was so far restricted. The third thinning reducing the stems to 25 per cent. can be marked in two ways. These are shown in the lower half of C at *a* and *b*. The growing space made available is shown in D at *a* and *b* respectively. It is hexagonal under the marking shown at *a* and square under the marking shown at *b*. No more, and in fact not more than two, such light *mechanical* thinnings are ever likely to be needed.

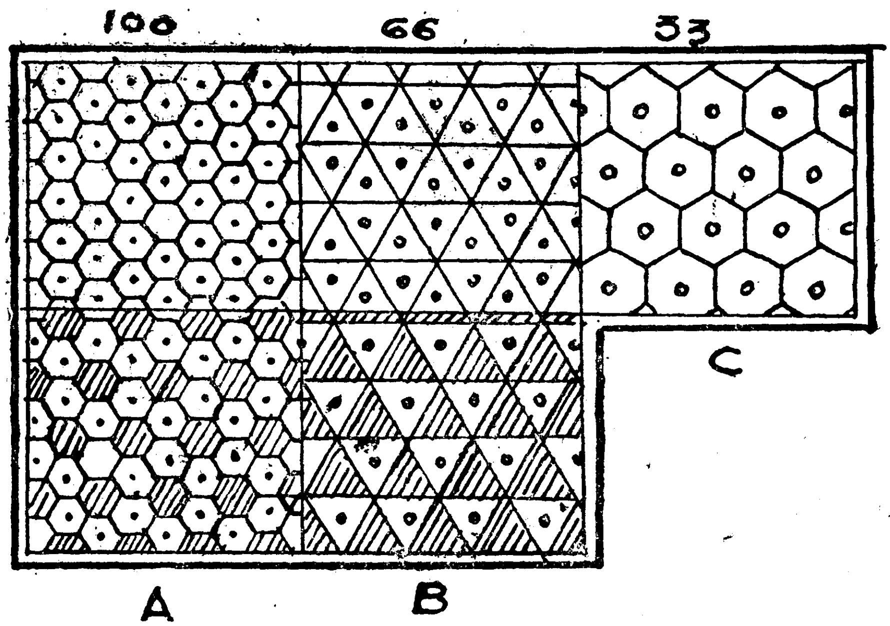
The one point that should be noted is that such very light mechanical thinnings giving uniform freedom to stems retained are not possible with square planting.

Light Thinnings (Fig. 4).—

Thinning ...	I	II
Stems retained ...	$66\frac{2}{3}\%$	$33\frac{1}{3}\%$

Fig 4

LIGHT THINNINGS



The upper half of A shows the unthinned crop with 100 per cent. stems. The first thinnings reducing the percentage of stems to $66\frac{2}{3}$ is marked in the lower half. The growing space made available for these stems is shown in the upper half of B. It will be seen that this is triangular in shape allowing plants equal freedom in three directions separated by 120°. The second thinning reducing the stems to $33\frac{1}{3}$ per cent. is marked in the lower half of B and the growing space made available is shown in C. This is hexagonal. No more mechanical thinnings are likely to be needed, and in fact by this time the stems would have developed well-defined crowns and the site-quality would have asserted itself, and thus the crops will have to be thinned on the individual merits of the stems.

Moderate Thinnings (Fig. 5)—

Thinning ...	I	II
Stems retained ...	50%	25%

The upper half of A shows the unthinned crop and the lower half the first thinning marked, reducing the stems to 50 per cent. The growing space made available is shown in the upper half of B: it is rectangular in shape. The second thinning reducing the stems to 25 per cent. can be marked in two ways as shown in the lower half of B at *a* and *b*. The corresponding growing space made available is shown at *a* and *b* of C; it is hexagonal or square in shape. No more mechanical thinnings are likely to be possible.

Heavy Thinnings (Fig. 6)—

Thinning ...	I	II
Stems retained ...	$33\frac{1}{3}\%$	11 1/9%

Fig 5
MODERATE THINNINGS

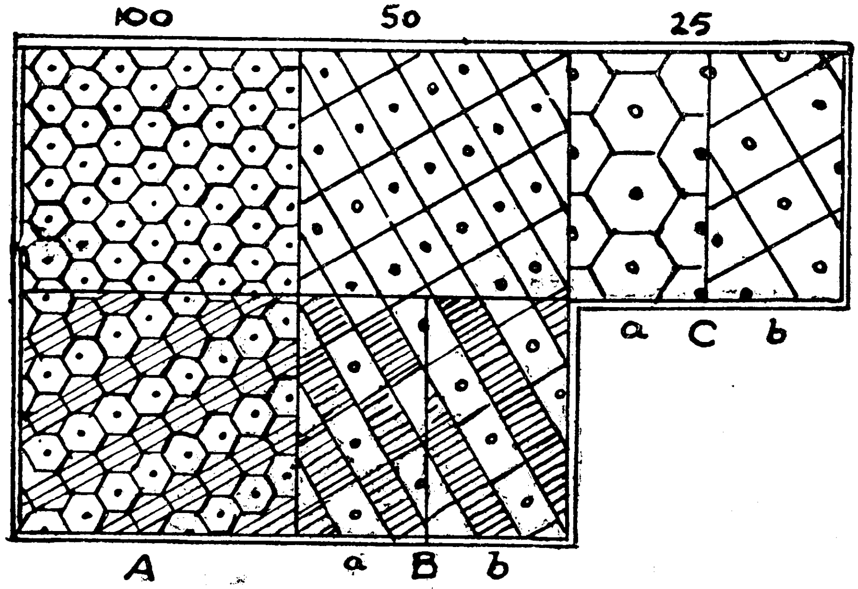
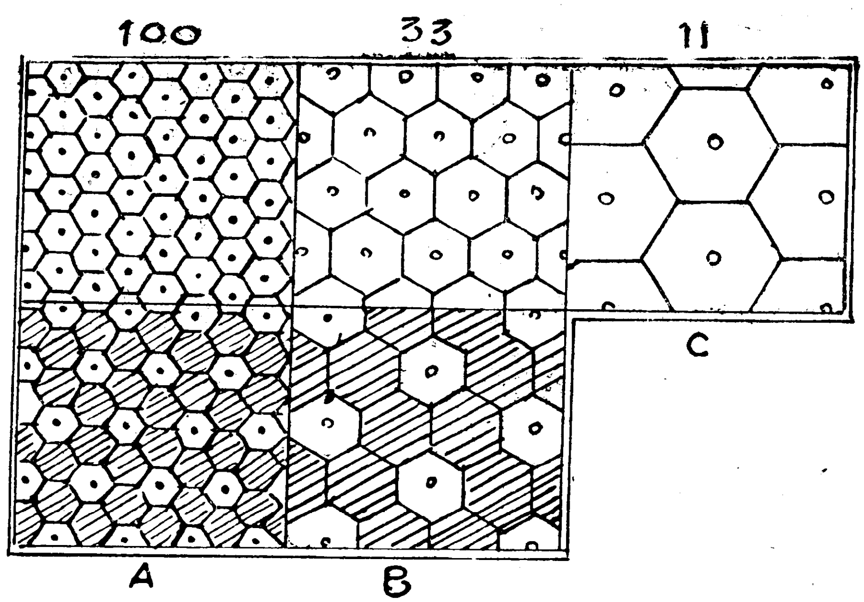


Fig 6
HEAVY THINNINGS



The diagram is self-explanatory. It will be seen that the growing space made available at each thinning is hexagonal in shape. If the second thinning to 11 1/9 per cent. stems is considered too drastic, any of the preceding grades of thinnings could be carried out instead.

Very Heavy Thinnings (*Fig.* 7)—

Thinning ...	I	II
Stems retained ...	25%	$6\frac{1}{4}$%

The diagram is self-explanatory and the same remarks apply to this as to the heavy thinnings illustrated in *Figure 6.*

Increment Fellings (*Fig. 8*)—

An increment felling at once reducing the stems to 14 2/7 per cent. is illustrated.

Such heavy fellings are only likely to be used for research purposes or for extremely fast-growing species grown for, say, bark production.

Fig 7

VERY HEAVY THINNINGS

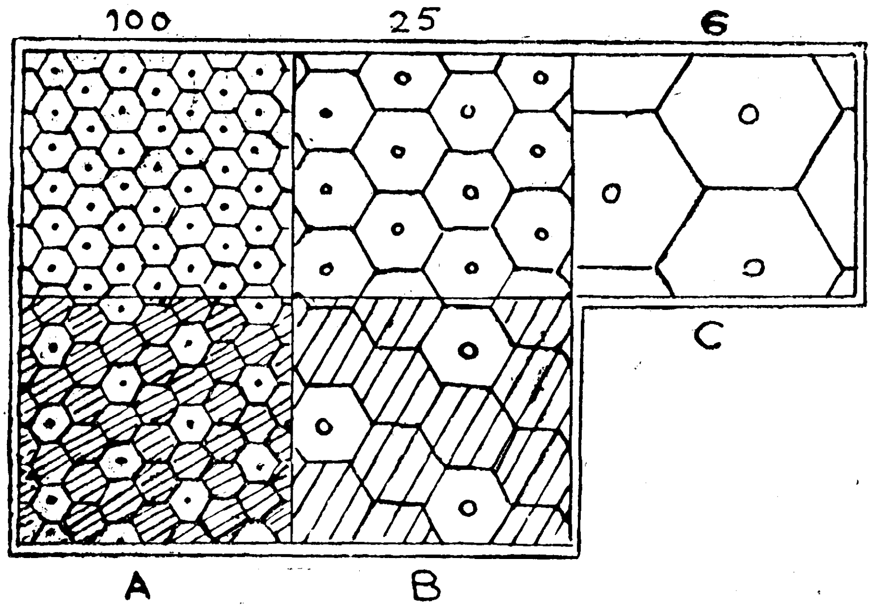
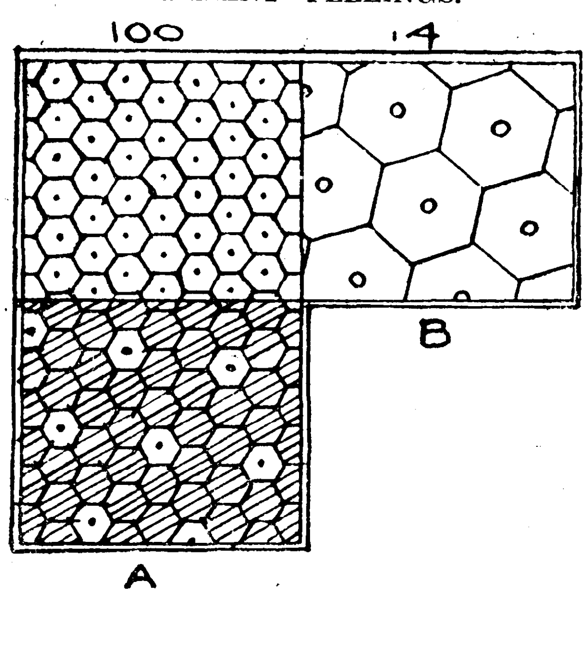


Fig 8

INCREMENT FELLINGS.



It will be readily seen that the various grades of thinnings possible in a triangularly planted crop are:

Before Thinning		After Thinning	
No.	Shape of G. S.	No.	Shape of G. S.
100	Hexagonal	75	Rhomboidal.
100	,,	66⅔	Triangular.
100	,,	50	Rectangular.
100	,,	23⅓	Hexagonal.
100	,,	25	,,
100	Rhomboidal	66⅔	Rectangular.
100	Rectangular	50	Hexagonal.
100	,,	50	Square.
100	Triangular	50	Hexagonal.

and thus actually a very large number of variations are possible.

To summarise, triangular planting is more akin to conditions obtaining in nature and has the additional advantage over square planting that crops can be mechanically thinned to various intensities in such a way that the plants retained have equal freedom to grow at least on two sides.

I would like to reiterate that these thinnings that I have illustrated merely show the *possibility* of carrying out mechanical thinnings, should they be still justified on silvicultural grounds which can be the case on uniform site-qualities and with rapidly growing species. When such is not the case thinnings must be carried out on crown classification basis or other considerations.

"NATURAL REGENERATION WITHOUT SEED-BEARERS"

By

C. W. D. Kermode, I.F.S.

The title of this article has been chosen on account of remarks which the writer found inscribed as a comment on one of the Burma experimental plot files in the Forest Research Institute. A better title would have been "The use of *taungya* in natural regeneration operations." The object of this experiment —badly expressed incidentally—is given as "Can natural regeneration of miscellaneous species in the mixed bamboo forests of Yanaungmyin reserve be obtained and established by cutting and burning and then tending the natural growth subsequently." The commentator remarked that he thought some seed-bearers of teak and other miscellaneous species should have been left "otherwise they cannot expect any regeneration." It would appear that the commentator had developed a certain amount of bias which should have been absent from one well versed in the esoteric mysteries of modern experimental methods. The thought of natural regeneration without seed-bearers was evidently too much for him. So it may be for a lot of other people. The object of this article is, therefore, to give a sketch of a regeneration

technique which has been applied in certain types of forests in Burma for the last few years and which, as far as it has gone, shows every promise of producing surprisingly good results. The method is only in its infancy but if it lives up to its early promise it may well revolutionise regeneration operations in some areas.

Artificial regeneration by means of *taungya* is so well known now that it hardly needs explaining but in view of what is to follow a few words are necessary about it. Briefly it consists of the raising of a planted tree crop in conjunction with agricultural, vegetable or even fruit crops. The area to be regenerated, after all marketable timber has been removed, is handed over to the *taungya* cutters who fell everything that is left on the ground, burn all this felled material as soon as it is thoroughly dry, then in the rains grow their own crop and in addition plant tree species at a spacing which is almost universally in Burma now six by six feet. At the end of the first year, when crops are reaped, or later in some of the more specialised *yas* where crop cultivation may go on for several years, the Forest Department takes over a plantation of young trees which has to be kept weeded and cleaned and later on thinned. The method is so well known and used in Burma that in some Lower Burma divisions the year's taungya operations go through like a drill movement. In fact there were for a time in use in some divisions ten forms on each of which was one order. These dealt with date of seed collection, date of felling, date of burning, etc. They were all issued in due season by the Divisional Forest Officer to the range officer who had to return each by a specified date stating that the order had been carried out.

This method of raising a young tree crop paid no attention to any regeneration that was on the ground before the *taungya* was cut. In fact there was no particular reason to take an interest in it. The area was to be planted up with a new crop, usually of one species, which was suited to the soil conditions and which would be, or was expected to be, much more valuable than the natural crop, already disposed of. It was generally assumed that whatever regeneration was on the ground before cutting the *ya* would be largely destroyed by the fire and subsequent cultivation. It was known that vigorous stumps of trees up to several feet in girth often escaped destruction and sent out coppice shoots. Any such natural regeneration that survived or that came up from seed on the ground or accidentally brought in from outside was welcomed as affording a mixed understorey to the main planted crop which would help to preserve the soil and check erosion. So little was expected of it, however, that for years it was the custom to broadcast seeds of accessory species which it was hoped would perform the functions mentioned above. Instructions were that any natural growth or growth from broadcast sowings was to be carefully preserved during weedings. In practice this was at times apt to be difficult or impossible on account of the dense growth of weeds such as *Eupatorium* or *Imperata*. Careful selective weeding through a mass of this stuff would have increased weeding costs greatly so it often became the practice to weed carefully along the planted lines and cut everything between the lines. In spite of this some natural did survive.

Now generally speaking, *taungya* regeneration for the mixed deciduous forests had for years been regarded as the only really feasible way of dealing with large areas in a satisfactory manner. Particularly did this apply to the mixed forest containing bamboo. Natural regeneration methods had been tried with a certain amount of success but had proved to be very costly owing to having to keep the bamboo continuously cut. Regeneration did not come evenly and the result usually was blocks of regeneration of a few acres each scattered throughout the compartment being regenerated.

During the great depression period in the early thirties there was a considerable controversy about the making of plantations and following this Government issued instructions which limited the area which could be made

annually. This area was considerably less than the area being planted each year. At the same time it was laid down that in future more attention should be paid to natural regeneration operations. These instructions were issued somewhere about 1935-36. From then until the fall of Burma natural regeneration operations developed on a considerable scale in forests in which previously natural methods had not been much employed. Two factors were responsible for stimulation of interest in natural regeneration work—that is apart from Government's orders. These were (1) a large scale flowering of the bamboo *Bambusa polymorpha* (*kyathaung*); (2) the increasing demands for forest produce for villagers use from the most accessible forests.

One fact which was learnt from the flowering of the bamboo and which has a bearing on the methods to be described was that on the ground there was a great deal of unnoticed natural regeneration both of teak and other species which only needed the removal of overhead cover to give it a chance. A particular case may be quoted. Two compartments in one division had about ten years before been very heavily worked and practically everything of value removed. Parts of these two compartments were prescribed for regeneration by *taungya* plantations. There seemed to be no natural regeneration. The overwood was light, the undergrowth of bamboo was fairly dense and under that, come in as a result of the opening of the top canopy, a growth of *Eupatorium*. Shortly after the bamboo flowered it was found that a certain amount of teak was showing up above the undergrowth and cleanings and fellings of the overwood were done. As a result it was found that there was a magnificent stock of teak on the ground of which small patches approached plantation density. In areas where previous extraction had not been done suppressed natural regeneration began to go ahead after the flowering and wherever the overwood above good groups was of poor species this was felled.

The need for making arrangements to supply the many villages of the highly populated paddy plains of Lower Burma had become more urgent as the remains of the unclassed forest disappeared and owing to the poor state of the forest it was necessary to open large coupes for extraction annually. Something had to be done about regenerating such areas. The poor state of the forest needs some explanation. The types of forests involved range from dry teak in the north to evergreen in the south. *Indaing* and semi-*indaing* types also occur. Dry teak forest has generally been exploited by trade fellings in the past and very little done about regeneration. At one time plantations were made in this type but numerous failures were responsible for the conclusion that it was not suitable for regeneration by the regular *taungya* method. All that could be done appeared to be improvement fellings to free patches of promising regeneration. The forest generally consisted of a light overwood often with a good deal of teak and a dense undergrowth of bamboo. In its worst state it might be only a little bit better than a dry cane brake. The poor condition can be traced to several causes, *taungya* cutting by local villagers years ago before reservation, regular exploitation and theft—not all necessarily operating over the same areas.

In the poorer quality forests particularly the evergreen and semi-evergreen types regular exploitation had usually been on a small scale and had generally been by trade extraction of big *dipterocarps*. Some of the areas had also been opened to villagers who buy tickets for fuel, houseposts, and sawing logs and do their own extraction. In addition theft had been very heavy in some of these forests. The forest department has never had enough staff adequately to patrol all these forests which from a revenue producing point of view have been of very little value. Consequently they have been rather neglected. With political development and a general agitation for the supply of nearby available forest produce to villagers these accessible forests came into the limelight and a system of working them was in evolution. They had to be properly opened up and they had

to be regenerated. To open them up many coupes had to be opened each year in order that the villager should not have to go far afield to get his needs. Also it was found that often coupes had to be large as the degraded forest contained such a poor stock.

In many cases areas opened were larger than was justified by the estimated felling cycle and size of the felling series but as this was due entirely to the degraded state of the crop it was considered justifiable if a fully stocked crop could be got onto the ground after. 50 acres of well stocked forest would be equivalent to more than 250 acres of the present forest. This may seem an exaggeration but consider what the villagers want; practically only fuel and houseposts. In the degraded evergreen and semi-evergreen forest houseposts of suitable species would probably be not more than one per acre while trees suitable for fuel might be so big that the villager coming in for one or two cartloads of fuel would not be prepared to go to all the trouble of felling and splitting them.

The obvious solution would appear to be to make plantations. In practice this has been done in some of the isolated islands of forests out in the plains known as plains reserves. Many species had been tried and a certain amount of success obtained. Plantations had also been made in the accessible foothills but generally these were of teak and their original object was more for the purpose of growing valuable timber than for supplying village needs. In future no doubt the formation of regular *taungya* plantations will continue on suitable sites.

At the time these plantations were being made nothing like the enormous increase in area of forest to be opened had been visualised. When the opening up really started then the department was faced on the one hand with large areas to be regenerated and on the other by Government's orders restricting plantation making. Also types of forest never before dealt with had to be regenerated and nothing was known about the possibilities of making plantations of such important species as *Xylia* in these areas. Well a lot of trial and error work was done from which the present methods of dealing with these areas have evolved. It is natural regeneration although *taungya* is done but it is developing in some cases into a combination of natural and artificial.

The state of the dry teak forest has already been described. The result of exploitation over many years in the evergreen has been the production of a light forest of a very few big trees, usually scattered *dipterocarps* and smaller trees either too poor to be worth taking or of species of no value. Climbers form a dense mat covering the tops of the trees in places and shrubs and undergrowth may be dense.

As more attention began to be paid to these forests (the worst of them looking like *ponzos*)* it was found that on the ground there was quite a good deal of regeneration of mixed species. Some of it might be up to bigger than sapling size but this larger stuff had usually been so spoilt by its bamboo or climber covering that it was not worth while merely freeing it. The smaller stuff might be seedlings but usually appeared to be plants that had been in existence for some years annually burnt back. Regeneration was always there and later on when assessments were made it was found that it was there even under dense cover in surprisingly large amounts. The problem was how to get it through and not only that how, in areas that contained only species suitable for fuel, to introduce other species which would give good houseposts and timber.

There is no need here to go into the various different experiments in detail but results have got to the stage of demonstrating that ordinary *taungyas* made in several different types of forest will result in a crop which may in some cases exceed 80 per cent. of 6 ft. × 6 ft. plantation stocking. If *taungya* cultivation is not done then all overwood climbers bamboos,

* Secondary growth following shifting cultivation.

Fig. I.

December, 1940. Photo: C. W. D. *Kermode.*

Experimental plot in Dry Teak Forest showing regeneration at end of first growing season, Pyinmana Forest Division.

Fig. II.

December, 1938. *Photo: C. W. D. Kermode.*

Natural regeneration in Eastern Laterite Semi-evergreen Forest. The plot was cut over for a *taungya* and a crop taken off it. Tharrawaddy Forest Division.

etc. can be cut as for a *taungya* and burnt and the same result can be achieved. The former method is preferable on account of cheapness as nothing is paid for cutting also weeding is not necessary in the first year when the cutter is growing his crop. The alternative method of just cutting and burning produces better growth in the first year as, if regeneration is dense, the *ya* cutters must be allowed to lop the early coppice shoots interfering with their crops of all except very valuable species.

As an illustration it is now desirable to return to a consideration of the experiment mentioned at the start of this note. A plot of forest about five acres in which there was no tree growth of value was selected. The original type was poor quality dry teak verging onto semi-*indaing* and there was a lot of bamboo. Everything on the ground was cut and burnt in March 1940. There was the usual hot *taungya* fire. The intention had been to get *taungya* cutters to come and do all the cutting, etc. free in return for which they were to crop the ground but there was no demand for land and the soil was poor. As *taungya* cutters were not available no cultivation took place. The writer inspected the area in June and felt very depressed at its appearance then. There was a fine healthy growth of *Dioscorea* sprawling all over the ground with a few — very few — *Bombax* sprouts. This did not look too good and it appeared as if the fire had killed everything and there had been no seed on the ground to germinate. However growth started in this month and an enumeration late in the month showed that 73.9 per cent. of squares 6 ft. × 6 ft. contained regeneration. At the end of the growing season in December another enumeration was done and it was found that 86.1 per cent. contained regeneration. The percentage of squares containing teak was 8.1 and *Xylia* 4.7. Of these 5.5 teak and .8 per cent. *Xylia* contained plants 3 ft. and over in height. A photograph was taken in the plot in December 1940. Teak can be seen. Open natural forest with dense bamboo lies in background (*Fig.* I, *Plate* 11).

It is necessary to digress for a bit and describe the assessment. Indicator lines were run out across the plot and six feet squares were enumerated on each side of the lines. The indicator lines were marked and subsequent assessments were done over the same lines. 17.4 per cent. of the total area of the plot was counted. Every square which contained a young tree was counted as stocked. If there were more than one in any square it made no difference as the square was stocked when it had one only. Where teak and *xylia* were found they were distinguished from other species, teak being given precedence. For example if a square was found in which there happened to be one teak and two *xylia* it was enumerated as one square stocked with teak. The tallest tree in each square did not necessarily count towards its stocking, the most valuable species did. In tendings of course the less valuable species would be later on eliminated if it was interfering with the valuable one.

By enumerating like this figures for stocking can be immediately compared with those of a plantation formed at the usual 6 ft. × 6 ft. A good teak plantation should be 95 per cent. and over stocked when taken over. The result at the end of the first year was, therefore, in the example given, a stocking which compared very favourably with plantation stocking.

A shock was administered to the writer when Dehra Dun commenting on the first counts made in June stated that the stocking was not 73.9 per cent. as claimed but 6.13 per cent. This did not look so good and a full explanation of the method had to be given. It was argued that in a plantation, when it was enumerated at the end of the first year, each seedling was counted as one and if there were 1210 squares per acre each with one surviving seedling then the plantation was 100 per cent. stocked. Similarly for this method; once the *taungya* had been cut and burnt then the resulting growth had to be looked upon as if it were a plantation. It was completely freed from overhead cover and it would be kept

weeded. No further regeneration was expected from outside and there could be none from seed-bearers. It was therefore quite justifiable to count each square which contained a seedling as stocked. This argument was accepted As in a plantation it is the stocking at the end of the first season that counts. In plantation work it is now accepted that usually it is not much use filling up blanks in the second year. Similarly here, there would be no attempt to increase stocking by any artificial means in subsequent years. Enumeration of stocked squares was the best method of getting a picture of regeneration as, though it did not necessarily give the total number of young trees on the ground, it gave a picture of the distribution.

Records of counts in 1941 at the end of the second growing season are unfortunately lost but the writer can remember what it looked like. Vigorous regeneration was everywhere. Down on a flat there was a patch of teak that looked like a poorly stocked plantation and trees had reached 10—12 ft. On the hillsides stood out great bushy growths of cutch, *Cassia fistula* and other species 10—12 ft. high with here and there a teak. *Xylia* was also present but not so tall. The plot was in fact a patch of well stocked young dry teak forest with bamboo eliminated. It all seemed so easy and natural. One senior officer who had not actually seen any experiments and was a believer in plantations called the method rather sneeringly the Montessori system. When argued with it was found that he could not believe such a method could be successful because it was too easy. Much more toil and sweat were considered to be necessary before regeneration could be achieved.

One more plot must be mentioned. This was in eastern laterite semi-evergreen forest in Tharrawaddy division. The plot started as an experiment by the Divisional Forest Officer to see if he could make plantations in this unpromising area. The writer saw it at the end of its first growing season (December 1938) and asked if he could take it over as an experimental area. It was not the planted crop that was so interesting, though that was fair enough, but the amazing amount of natural regeneration on the ground (*Fig.* II, *Plate* 11) which had survived in spite of the fact that a field crop had been taken off and that there had been no restrictions on cutters about preserving shoots of natural regeneration. An assessment was made over 20 per cent. of the area and 74 per cent. of stocked squares of natural regeneration was found. At the end of the second year the percentage was 78 and at the end of the third 76. Growth for certain species of the natural is given below as well as growth of the planted species.

HEIGHT GROWTH OF NATURAL SPECIES

Species.	Average height in February 1939	Average height in March 1940	Average height in March 1941
	(Feet)	(Feet)	(Feet)
Pyinma (Lagerstroemia flos reginae). ..	3.2	6.6	8.8
Zaungbale (Lagerstroemia villosa) ..	3.0	8.8	12.7
Aukchinsa (Diospyros sp)	1.6	4.4	9.4
Thande (Sterospermum sp) ..	2.1	6.8	10.9
Petthan (Heterophragma sp) ..	1.7	5.6	8.5
Nagye (Pterospermum semisagittatum)	2.0	5.1	8.1
Myatya (Grewia sp)	3.6	7.9	11.3

HEIGHT GROWTH OF PLANTED SPECIES

Species	February, 1939	March, 1940	March, 1941
	Feet.	Feet.	Feet.
Pyinkado 6ft. × 6ft.	.8	2.7	5.3
„ 12ft. × 3ft.	.6	2.7	5.5
„ 18ft. × 3ft.	.9	3.5	7.6
Zaungbale 6ft. × 6ft.	.9	5.0	7·2

A cleaning and thinning of the surplus shoots of some of the natural was to have been done in January 1942 and the plot was then going to be left until a thinning was due. Two more plots were laid out in this type in 1940 and results were equally good. In one plot left uncultivated but weeded percentage of stocked squares was 72 while in the second cultivated by *taungya* cutters the percentage was 83.4.

More plots were started in 1941. Assessments were to be done in December 1941 and were no doubt carried out but the results were not seen and have now been lost. Inspection of the 1941 plots in the 1941 rains however showed that there was any amount of stuff present. Plots were in dry teak, semi-*indaing* and eastern laterite semi-evergreen. In some *taungya* cutters had cultivated, in others the resulting natural was being tended.

There is a great deal more experimental work to be done. It has got to be determined for one thing how much regeneration must be on the ground before the *taungya* fire to give an adequate crop after. Another important point for investigation concerns regeneration of *Xylia*. Sometimes after a seed year the ground is carpeted with seedlings. It is desirable to discover whether a *taungya* can be cut over these seedlings at the end of their first year and leave enough on the ground alive to form a well stocked crop or whether they have got to be left until they are a bit older before it is safe to cut and burn. Figures from indicator line counts gave in natural forest for dry teak in various areas, 41, 65, and 72 per cent. of stocked squares, and for eastern laterite semi-evergreen 60, 62, 66, 86, per cent. In the semi-evergreen a total of 24.3 acres of indicator lines were counted. In both types there was a fair amount of growth above sapling size. This was not counted. The percentage of stocked squares shown is therefore probably lower than it should be. There is no reason to suppose that these lines contained much less than did the two plots dealt with in detail above. Therefore it is a reasonable assumption that an extraordinarily small amount of what is on the ground gets destroyed. Now the critic can remark "all very well but in many forests there is no regeneration on the ground." The reply to this is—count it out and see. There is far more than is generally realised. Also don't set a standard of requirements of several thousand trees per acre. Less than a thousand per acre is enough.

This method can in a way be looked upon as a form of coppice regeneration in which the *taungya* is the coppicing and cleaning. What comes up in addition to seedlings is from stools that in some cases may be of seedlings of the year before, in other cases of seedlings that have been burnt back to ground level year after year and in others from stools of saplings of fair sized trees. But the great majority of what comes up however is derived

from root stocks that have never produced a tree even of sapling size. Another example of this type of regeneration may be quoted. In pure *Dipterocarpus tuberculatus* forest the ground is often carpeted with "seedlings". These get burnt back year after year and develop into "cabbages". They will not grow up under the shelter of an overwood. When the overwood is removed they immediately start to grow. This regeneration is really in a way coppice because the seedlings have been burnt back year after year but they have probably never developed a stem over 2 ft. in height.

In addition to the experimental work full scale work was carried out at a number of centres in several divisions where *ya* cutters could be induced to come in and cut free. At first this work tended to be a compromise between natural and artificial as, in order to make sure that here should be sufficient regeneration on the ground, seed was sown either broadcast or in lines, stumps were put in and some transplanting was done. In fact in the initial stages far too much was put on the ground. The object of this intensive planting and sowing was to avoid weeding costs. It soon came to be realised that a lot of this supplementing was quite unnecessary furthermore it was an actual waste because generally only second rate species were being used. Later developments have been, in those types of forests in which valuable species were absent, to plant stumps or sow seed of species like teak and *Xylia* at such wide spacings as 15 ft. × 15 ft. or 18 ft. × 18 ft. The ultimate result may be that all plantations of the future which are in very accessible areas will be raised by this method. The valuable species will be introduced at something like final crop or half final crop spacing and will be brought up during life in a matrix of natural forest. Thinning operations will remove trees of other species and these thinned trees will go to serve the needs of the local villages for fuel and in some cases houseposts. The final crop may be houseposts but they will be valuable houseposts which only the rather better off people will be able to afford—the poor man will get his needs from the cheaper type of houseposts from thinnings.

Apart from village supply forests the method will probably be the one used in future to regenerate dry teak forest. Such forest is not usually suited for making regular plantations. There is usually a fair amount of burnt back teak regeneration which by itself is normally enough to give an adequate proportion of teak in the new crop. If it is not considered enough then a few stumps can be put in in places where it is deficient. Assessments of regeneration on the ground before regeneration starts will show whether valuable species are already there or not and the necessity of supplementing or otherwise can be decided before operations begin.

A further development lies in investigations of crops suitable for the poorer quality soils which will be paying enough to encourage *ya* cutters to come in. A two-year scheme of cropping had been worked out with an agricultural expert and a list of crops suitable for growing on poor soil bearing poor dry teak forest or semi-*indaing* had been made. Experiments were to have started in 1942 rains but fate decreed otherwise.

ANDAMAN FORESTS AND THEIR REGENERATION—I

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TABLE OF CONTENTS

CHAPTER I—THE ANDAMAN ISLANDS

The Andaman islands, about 204 in number, with an area of 2,508 sq. miles are situated in the South East of Bay of Bengal between latitudes of 92° 11′ and 93° 7′ East. Many of them are small and support not more than 30 or 40 trees, some of them are just awash, or are submerged at high tide and are, in addition to extensive coral reefs, a source of great danger to coastal navigation. The main islands are North Andaman, Middle Andaman, Baratong and Rutland. These are separated by very narrow straits, and may be regarded as forming a single island 156 miles long and about 15 miles broad. Other islands of importance are the Landfall Islands to the North, Interview Island to the West, the Labyrinth Islands to the South West. Porlob, Long Island, North Passage, Colebrooke and Strait Islands on the East, all hug the main islands. The Havelock, Lawrence, Outram and Wilson islands form the Richies Archipelago and lie 5—15 miles east of Middle and South Andaman islands.

COAST LINES

The coast lines of these islands are very irregular with deep and numerous indentations, giving rise to safe harbours for sea-going steamers. In fact, the fleet formed for the attack on Burma in 1824 was able to make its rendezvous at Port Cornwallis. Tidal creeks run many miles inland, literally cutting the islands into the shape of a bipinnately sect leaf. This makes the transport of timber extremely easy.

CONFIGURATION

The Andaman islands are a mass of hills, and the main range of hills runs North and South and rises to a height of 2,402 ft. in Saddle Peak in North Andaman. From these hills, ridges and spurs run in a confused manner, enclosing narrow valleys or a mass of sweeping undulations. Level lands are rare except along creeks or river banks and the sea coast. There are no large rivers, and perennial streams are rare.

CLIMATE

The climate is warm and equable, the mean temperature in the shade varying from 70°F to 90°F, with a perceptible touch of cold during December and January, when fogs and some chilly nights are common. February to April is sultry with very little wind. The average rainfall is about 120 inches, but varies from place to place. Precipitation generally occurs every month, though the bulk of it falls from June to October. Both South West and North East monsoons blow with regularity from May to October, and from November

to January respectively. Cyclones rarely occur, though stormy weather conditions prevail at the beginning of the South West monsoon in May—July and also at the change of monsoons from the middle of October to the end of November.

GEOLOGY

These islands are the summits of a submarine range of mountains, running from Cape Negrais in Burma to Achim Head in Sumatra. The underlying rocks over the greater part of the islands are chiefly non-micaceous hard coarse grained sandstone, indurated clays and slates, conglomerates, pale grey limestones and indurated and altered intrusions of serpentine. Coral formation is found along the coasts. Soft limestone, chiefly of shell sand, soft calcareous sandstones, and white clays with occasional conglomerates are the chief rocks of the Richies Archipelago. The white clayey limestone cliffs in some of the Archipelago islands can be seen from a distance of 25—30 miles.

SOIL FORMATION

The following types of soil formation are easily distinguished and are of considerable importance to the Forester, as the distribution of forest types depends almost entirely on the presence or absence of a particular soil. The main types of soil are:

1. SALINE ALLUVIUM

This is fairly deep and is formed by the clayey or sandy loam deposits brought down by rain water, or by the streams, from the adjoining rising ground. This is found in all bays and creeks, and also along coast line usually sheltered from surf. It forms about 18 per cent. of the total area and is inundated at regular intervals by the rise and fall of the tides.

2. ORDINARY ALLUVIUM

This consists chiefly of a deep fertile clayey loam, or sandy loam, formed in the same way as the saline alluvium. It is out of reach of sea water but very often in the rainy season, because of its impermeable nature, it holds water on the surface for a considerable time. During this period logging work in this area becomes extremely difficult, as the soil becomes a mass of puddled clay, resulting in elephants with their logs sinking knee deep or more. This formation is found along the creeks above the saline alluvium, or along the coast between the sandy beach and the hilly ground, along stream margins and in valleys and depressions. The extent of this formation is about five per cent. of the total area.

3. SANDY BEACH

Consists chiefly of sand and shingle, mostly calcareous, lumps of old coral and broken shells raised by the action of wind and waves just above the reach of high tides. It is extremely porous, and the streams coming down from the hills disappear here to emerge again at sea level or in the sea. This formation is limited to the sea coast and is usually a narrow belt or a small strip.

4. UNDULATING GROUND

This is formed by the disintegration of indurated clays and shales, limestones and conglomerates, the matrix of which is mostly clayey and hard coarse grained non-micaceous sandstones. The soil varies from clayey loam to a coarse rubbly sandy loam and is very shallow in some places. There is no trace of visible humus. It is rich but is dry and water-less in the dry season. It is confined to the lower slopes and the undulating ground between the alluvium and the hills. and it forms by far the largest area about 45 per cent. This formation is rarely found beyond an elevation of 300 ft.

5. HILLS

The hills consist of stiff clayey soil, of dark red loam overlying a micaceous sandstone formation. It is moist throughout the year and there is no scarcity of perennial springs, though the flow of water in the dry weather is small, chiefly due to the catchment areas being small. The high and steep hills, such as Saddle Peak and Mount Ford, consist of hard red brown infertile soil with an underlying rock, very often of an intrusive serpentine.

CHAPTER II—THE ANDAMAN FORESTS

FACTORS INFLUENCING FOREST TYPES IN THE ANDAMANS

The climate, the soil and the past treatment are the main factors influencing forest types in a locality. The Andaman Islands, except for a few wild tribes who have no use for timber, were practically unoccupied until 1858. Since then, about 70 sq. miles have been cleared in the vicinity of Port Blair for the establishment of a settlement. But, until 1870 teak was imported from Burma for all buildings and any timber obtained in the course of clearing, including padauk, was considered useless and was burnt along with other brushwood. The Forest Department was formed in 1883 and it began on a very small scale with one officer, 200 men and 16 elephants, taking out about 2,000 tons of timber per year. It was a long time (about 1925), before the extraction figures reached 30,000 tons. With improved methods of extraction, mainly the elephant hauled short length tramlines, the extraction had reached 60,000 tons in 1941. Also the areas that were considered inaccessible were rendered accessible for economic exploitation. With the increase in accessible areas, the annual possibility of these forests also increased and Sir Herbert Howard, Inspector-General of Forests, after a careful and thorough examination in 1941, found that the yield with a 150 year rotation can be 1,36,000 tons of timber per annum, *vide* his "Note on a tour of inspection in the Forests of the Andaman Islands." This definitely shows that the exploitation of these forests has been only a fraction of what it could normally have been. Moreover these extraction fellings were confined mainly to the coastal areas, and to the areas within half a mile of any tidal creek from which timber could be rafted easily. Beyond this, with only elephants as the motive power to move the logs from stump site, it was considered uneconomical to exploit these forests. Thus, except for about 70 sq. miles cleared for settlement round about Port Blair, and also for the removal of exploitable trees along the coastal fringes and tidal creeks, the whole area is covered with virgin forests, never touched and, in some cases, never explored by any civilized man.

Of the other influences, fire sometimes caused by natural agencies like lightning etc., and invariably caused by human agencies, is the chief factor in influencing forest types in a locality. It holds back the seral progression and has, indeed, enabled *teak* and *sal*, India's most important timber trees, to hold their own, in conditions in which, if fire is excluded, they would disappear, being unable to regenerate themselves in competition with the more shade enduring species that come up as a natural sequence in the progressive succession towards the climatic climax. In fact it is in the seral stage that we find the most economically important forests of the present day, and Foresters are to-day faced with the problem of maintaining these forests in that preclimax stage.

The climatic conditions prevailing in the Andamans are purely tropical, with a mean annual temperature of over 75°F. as shown below: —

January		May		July		November	
Mean	Diurnal range	Mean	Diurnal range	Mean	Diurnal range	Mean	Diurnal range
81.1	10.8	83.8	10.7	81.5	8.0	82.0	9.6

The mean annual rainfall is over 100 inches, distributed throughout the year as shown below:

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.04	0.72	0.43	3.02	16.64	18.71	15.06	14.40	18.84	11.61	9.44	6.52

(This observation was made in Ross Island, one of the driest parts in the Andamans.)

This rainfall makes a forest fire impossible. Thus, with the elimination of biotic influences, and with the pronounced tropical rainy climate, it is natural to expect climatic climax forests *i.e.*, complete wet evergreen forests. But, a careful perusal of the description of these forests will show, that a large percentage (nearly 50 per cent.) is still in seral stage, with *padauk* (*Pterocarpus dalbergioides*, white *dhup* (*Canarium euphyllum*), *gurjan* (*Dipterocarpus* spp.) and other valuable species—all deciduous or semi-deciduous, still forming the main canopy. Also that the formation of different types of vegetation is purely edaphic and follows closely the classification of soils. As the hills are not very high—the highest is only 2,402 ft.—aspect has very little influence on the modification of forest types in the Andamans. The general character of the growth, except in dry months, appears to be uniform throughout. Deciduous and evergreen forests grow on similar elevations, on similar aspects and in regions of similar rainfall, the sole deciding factor being the soil and the subsoil.

THE FOREST TYPES

According to Champion's classification ("forest types of India and Burma," page 15) the forests in the Andaman Islands may be divided into:

A—Edaphic preclimax forests, or forests influenced by site factors in addition to climatic factors.

1. Tidal Forests (Mangrove forests).
2. Beach Forests (Beach forests).
3. Riverain Forests (Low level evergreen forests).

B—Tropical or climatic forests.

4. Moist deciduous forests (Deciduous and semi-deciduous forests).
5. Wet evergreen forests (Hill or high level evergreen forests).

N.B.—The classification within brackets is the classification that was in common use in the Andamans.

GENERAL DESCRIPTION OF THE FORESTS

Except for about 70 sq. miles cleared for the settlement, the whole area from the water's edge to the summit of the highest hills is covered with a luxuriant growth of dense forest, characteristic of a region of warm climate, heavy rainfall, and high atmospheric humidity. As a rule, from the ground level up to about 150 ft. or more, it is one mass of green vegetation, tangled together by enormous climbers, thorny canes, and the impenetrable climbing bamboo which carpets the lowest ground and festoons the highest trees. Scrub jungle on high hills and on very steep slopes is the only exception to this rule. Sir Alexander Roger, in his tour of inspection as Inspector-General of Forests in 1927, says that he has never seen a denser forest in any part of India or Burma.

DESCRIPTION OF THE FOREST TYPES

Tidal forests (Mangrove forests).—These forests, locally called Mangrove forests, occupy the saline alluvium and line either side of nearly all the creeks, and portions of the coast line sheltered from the force of the wind and waves. Fringing the coast line, and occupying the lowest elevation, these forests extend as far as the high tide can reach. Growth is very level and, in some cases, they are clipped like a flat topped hedge by parakeets. These forests, with their heavy and

dark green foliage, are a very pleasing relief to the dreary expanse of the sea, and form a beautiful setting for other types of vegetation occupying higher elevations.

Of the species represented the most gregarious and predominating are *Rhizophora mucronata* and *Rhizophora conjugata*. These are found almost exclusively on the outer limits facing the sea. Closely set and forming a strong and effective sea wall with masses of stilt-like roots, they are extremely difficult to penetrate. Immediately behind this, on slightly more raised ground, and where the influence of fresh water is felt, are found two other species, *Bruguiera gymnorhiza* and *Bruguiera parviflora*. The former is the largest species of mangrove and is next in abundance and gregariousness only to the *Rhizophoras*. Where it does occur, it gives the appearance of a well tended plantation, with clear boles 60—80 ft. high, a girth of 5—6 ft. and with a clean floor except for the numerous knee roots. These four species form very good fuel and are considered next best to coal by the crews of the steam launches. *Avicennia officinalis*, with numerous pneumatophores, also forms occasional gregarious groups. Other species of true mangrove habit are about 15 in number but are not so common. *Ceriops candolleana, Kandelia rheedii, Carapa obovata, Carapa molucensis, Sonneratia acida*, S. *alba* and others are found dotted about everywhere. *Heritiera littoralis Phœnix paludosa, Nipa fruticens, Licuala spinosa Barringtonia racemosa, B. speciosa* and *Brownlowia lanceolata* form the outward fringe of the swamps that are reached only by the spring tide, and gradually give rise to other types of vegetation. It is estimated that about 160 tons of timber per acre are available (Inspector-General of Forests note on a tour of inspection 1928) and the area occupied is roughly 450 sq. miles, or 18 per cent. of the total area.

Beach Forests.—Just above the high tide and exposed to the full force of the monsoon winds, these forests are found lined along the coast in narrow belts from a few yards to a furlong or more in width. They grow on sandy beach formed by sand and shingle banked up by wind and waves, and also on the detritus brought down by streams. These forests act as very efficient shore protectors and wind belts, especially on the West coast where the contorted appearances of *Mimusops littoralis*, the predominating species of this formation, tells its own tale. On the loose knit sand, often reached by high tide, *Ipomaea biloba, Crinum asiaticum, Vigna retusa, Pandanus tectorius, Scaevola koenigii*, and a few others form the only growth. Behind these, and on firmer soil, only sometimes reached by high tide, we have *Hibiscus tiliaceus, Morinda citrifolia, Thespesia populnea, Pongamia glabra, Desmodium umbellatum, Gyrocarpus americanus, Erythrina indica, Barringtonia speciosa, Calophyllum inophyllum Terminalia catappa, Cordia subcordata*. Most of these lean out towards the sea, and sometimes, heavily laden with straggling shrubs and climbers such as *Colubrina asiatica, Caesalpinia bonducella, Mucuna gigantea* and various *Ipomeas*. *Mimusops littoralis*, the towering giant of the littoral forest, sometimes grows pure on flat and deep sand deposits. The total area of this type of forest is negligible and is about one or two per cent. of the total area.

Riverain forests.—Southern tropical semi-evergreen (Low level evergreen forests).—Leaving the tidal and beach formations, unless the ground rises abruptly, we come to what may be termed the low level evergreen forests; the densest in the Andamans. This type is confined mostly to the ordinary alluvium, which forms the banks of larger streams, moist valleys and depressions, and the inner extensions of tidal flats. This alluvium is immature but is sufficiently old, and sufficiently raised above flood level to give rise to a magnificent growth of the species found both in deciduous and in evergreen area, very often with huge buttresses. Climbers and cane brakes are very heavy and make penetration extremely difficult.

Dipterocarpus alatus, the biggest and the grandest tree of the Andamans, with its usual associates *Dipterocarpus pilosus, Sterculia*

alata, S. campanulata, Terminalia bialata, T. procera, Albizzia stipulata, A. lebbek, Calophyllum spectabile, Bombax insigne, Artocarpus lakoocha, A. chaplasha and *Pterocarpus dalbergioides* form the predominating species and occupy the topmost storey of 100 ft. and over. Below this, forming the 2nd storey between 50—100 ft. are found *Lagerstroemia hypoleuca, Dillenia pentagyna, Dracontamelum mangiferum, Pometia pinnata, Myristica irya, Pisonia excelsa Litsaea panamonja, Xanthophyllum andamanicum,* and many others of less importance. Forming the lowest storey are found *Fagraea morindifolia, Talauma andamanica, Garcinia andamanica, Macaranga tanarius* and *Aporosa villosula.* The ground is usually covered with *Saprosma ternatum, Maesa andamanica, Micromelum pubescens, Clerodendron infortunatum, Leea sambucina* and *L. acuminata, Clinogyne grandis, Licuala peltata, Caryota mitis Areca triandra, Oxytenanthera nigrociliata,* and also *Saccharum* in open places.

Of the climbers and straggling shrubs and canes, *Dinochloa andamanica* (a climbing bamboo), *Thunbergia laurifolia Ipomaea* spp., *Buettneria andamanensis, Combretum extensum C. chinense, Deamonorops kurzianus, D. manii* and *Calamus palustris* form a rampant growth trailing over the ground and climbing into the highest trees. Only the top storey trees, and a few in the 2nd storey, are really deciduous and that, only for a short time.

Tropical moist deciduous forests.—Rising from the tidal, the beach or the Riverain (the low level evergreen forests) and covering all the undulations, and extending 300 ft. or more up the hills and ridges as far as the soil conditions permit, these forests (locally called *padauk* forests), form the most important reserves of timber wealth of these islands. They cover as much as 45 to 46 per cent of the total area.

Padauk the most important and predominating timber species of these islands, with its equally important associates *Terminalia bialata, T. manii* and *T. procera. Canarium euphyllum, Sterculia campanulata, Bombax insigne, Lagerstroemia hypoleuca, Tetrameles nudiflora, Chukrasia tabularis,* and in moist localities *Artocarpus chaplasha, Dipterocarpus alatus, Parishia insignis, Bassia butyracea* and *Albizzia lebbek,* form the topmost storey over 100 ft. in height. These trees, with their huge buttresses (especially in the case of *Tetrameles nudiflora, Padauk* and *Terminalia bialata*) are scattered and their widespread crowns rarely meet. Below these giants, and forming the second storey of over 50 ft. and making a fairly complete canopy, are *Lannea grandis, Adenanthera pavonina, Sterculia villosa, Dillenia pentagyna, Aglaia andamanica, Diospyros marmorata, D. pilosula, D. pyrrhocarpa, Miliusa tectona, Sageraea elliptica, Cratoxylon formosum, Semecarpus kurzii, Zanthoxylon budrunga, Celtis wightii, Cinnamormum zeylanicum, Cobtusifolium* and *Pterospermum aceroides.* Below these, forming the third storey are found *Murraya exotica, Atlantia monophylla, Limonia alata, Canthium glabrum, Ixora grandiflora, Grewia laevigata,* and the small bamboos, *Oxytenanthera nigrociliata* and *Bambusa schizostachyoides.*

Of the shrubs covering the ground, the most common are *Alsodeia bengalensis, Mallotus acuminatus, Actephila excelsa, Randia longiflora, Harrisonia brownii, H. bennettii, Glycosmis pentaphylla* and *Licuala peltata.*

The most common climbers and straggling shrubs, which connect these different tiers in the canopy, are *Ventilago madraspatana, Delima sarmentosa, Buettneria andamanensis, Acacia pennata, Entada scandens, Plecospermum andamanicum Sphenodesme unguiculata* and a variety of canes.

Tropical wet evergreen forests (High level evergreen forests).—This is confined to the hills and ridges and to the serpentine outcrops, which emerge abruptly from the deciduous forests, which may be termed high level evergreen forests. It is on these outcrops, and on the lower slopes of the higher hills that we have the true and the most luxuriant growth of evergreen forest. the grandest of all the Andaman forest types.

Every tree is clear boled and reaches great heights, requiring field glasses clearly to see their leaves. The principal species, *Dipterocarpus grandiflorus* and *D. pilosus* together with their associates. *Artocarpus chaplasha* and *A. gomeziana, Calophyllum spectabile, Planchonia andamanica, Hopea odorata, Endospermum malaccense, Sideroxylon longipetiolatum,* and occasional *padauk* and white *dhup* (*Canarium euphyllum*) form the upper storey. Below these, forming the second storey between 50—100 ft., are found *Xanthochymus andamanicum, Pometia pinnata Messua ferrea, Baccauria sopida, Podocarpus nerifolia, croton argyratus, Pterospermum aceroides* and *Myristica* spp. Small trees are few and they are mainly *Mitrephora prainii, Actephila excelsa* and *Caryota mitis.* The chief climbers are *Dinochloa andamanica, Gnetum scandens, Ancistroctadus extensus* and a variety of canes. These connect the crown above, and lie in snake like coils on the ground below.

On high hills, such as Saddle Peak in the North Andaman, Mt. Ford in Rutland Island, and also on some of the ridges in other islands, with hard red brown infertile soil, the magnificent height growth of trees, found in other formations, disappears. The trees become small and stunted, rarely more than 30 ft. in height and 2—3 ft. in girth. They are more numerous and grow close to one another. The main species in this formation is *Dipterocarpus costatus, with* occasional *Messua ferrea, Cratoxylon formosum, Canarium manii,* and *Hopea andamanica.* The main shrubs are *Memecylon caeruleum* and some varieties of small bamboos, and also a variety of *Phoenix.*

PRESENT CONDITION OF THE FORESTS

Though the Andaman forests are very dense, the proportion of really valuable species is very small and these are found scattered in a useless crop all over the area. Recent clear fellings in regeneration areas showed that very rarely is the yield per acre of merchantable timber more than 16 tons. Sir Herbert Howard, in his note on a tour of inspection in the forests of the Andaman islands, page 6, says "The average yield from a clear felled area at present is about 15 tons per acre though many areas give a good deal more . . . . I saw in the Happy Valley a place where 70 tons per acre was actually standing and it was not by any means fully stocked." It is therefore clear that these forests, as far as valuable trees are concerned, are very poorly stocked indeed.

The present condition of the crop is that the valuable species. with few exceptions, are mostly deciduous or semi-deciduous, and occupy the topmost storey. These are overmature with a large percentage of hollow and unsound trees. Younger age classes are very poorly represented or even non-existent.

This is especially so, in the case of *padauk* which remains sound until it reaches a girth limit of 9 or 10 ft. After this, it usually becomes unsound, but continues to grow to enormous size. Trees of 25 to 30 ft. girth, completely hollow and with only a thin shell, are a common feature in these forests.

Below these trees, everything is evergreen and is of little use at present. It forms a thick and impenetrable mass.

The only exception to this general rule are the wet evergreen forests, in which the vegetation from the ground level is completely evergreen. The main crop, mostly *Dipterocarpus* (other than *alatus*) are mature or overmature. Younger age classes from the seedling stage are not wanting, though they are not found by any means to the extent desirable in a normal forest.

In all these types of forest (except tidal forests) the trees grow in the form of mixtures of single trees. *Dipterocarpus kerii* is, however, an exception, and grows pure with all age gradations represented from the seedling to the mature tree. But the area occupied by *kerii* is very small and is limited to Gobang in South Andaman. It is one of the most remarkable types of forest, forming the most excellent example of perfect uneven aged forest.

PROBABLE CAUSES FOR THE PRESENT ABNORMAL STATE OF THE FORESTS

Champion thought that the Andaman soil is still immature, and that the forests have not had enough time to reach climatic climax. The species now most valuable, *viz., padauk* and its associates are only transitory, and are gradually being replaced by climax formation. His observations were based on the recent description of the forests. Kurz in 1886, and Oldham in 1894, thought that these islands were the residue above water of a submarine subsidence which was still continuing, and this theory was further supported by Sir Richard Temple in 1901. Some other observers, however, are of the opinion that both subsidence and upheaval are still going on.

Recent upheavals and subsidences account for the fact that there are still areas, especially the riverain tracts, with an almost pure crop of *Anthocephalus cadamba,* a species which is one of the first to make its appearance in a new soil, and is also one of the first to make its disappearance with the progressive development towards climatic climax. The size of these trees, rarely more than 5 or 6 ft. in girth, clearly shows that at least these tracts are not very old.

Mr. B. B. Osmoston in 1908 (Indian Forest Records Vol. I Part III page 241) referring to *Padauk,* says "saplings and young poles, as well as trees below 6 ft. in girth are very scarce indeed. This remarkable disparity in the age classes can only be explained by assuming that there has been a recent change in the condition of the vegetation in the Andamans: the conditions under which the existing crop of mature and overmature trees arose, having given place to others unsuitable to the successful reproduction of *Padauk.*" Professor Troup, in his book, The Silviculture of Indian trees, says "Frequently the change takes place by reason of conditions (moisture, shade, etc.) produced by the formation itself." What is true of *Padauk* is also true of other deciduous and also of evergreen species, *viz., Gurjan* (*Dipterocarpus*) *lambapathi* (*Sideroxylon longipetiolatum*) and *Bakota* (*Andospermum malaccense*). Whatever may be the cause for this change, we have now got to face the fact that the Andaman species, now well known in the market, are only transient and a stage in the progressive succession towards climatic climax and may fade away unless Foresters step in and prevent this disaster.

(*To be Continued*)